Hille.

FILE COPY

O T T A W A May 29th, 1943.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1420.

Examination of a Failed Aluminium Alloy Rivet Joint.

(Copy No. 10.)

Bureau of Mines
Division of Metallic Minerals

Ore Dressing and Metallurgical Laboratories

CANADA

DEPARTMENT
OF
MINES AND RESOURCES

Mines and Geology Branch

O T T A W A May 29th, 1943.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1420.

Examination of a Failed Aluminium Alloy Rivet Joint.

==========

Origin of Problem:

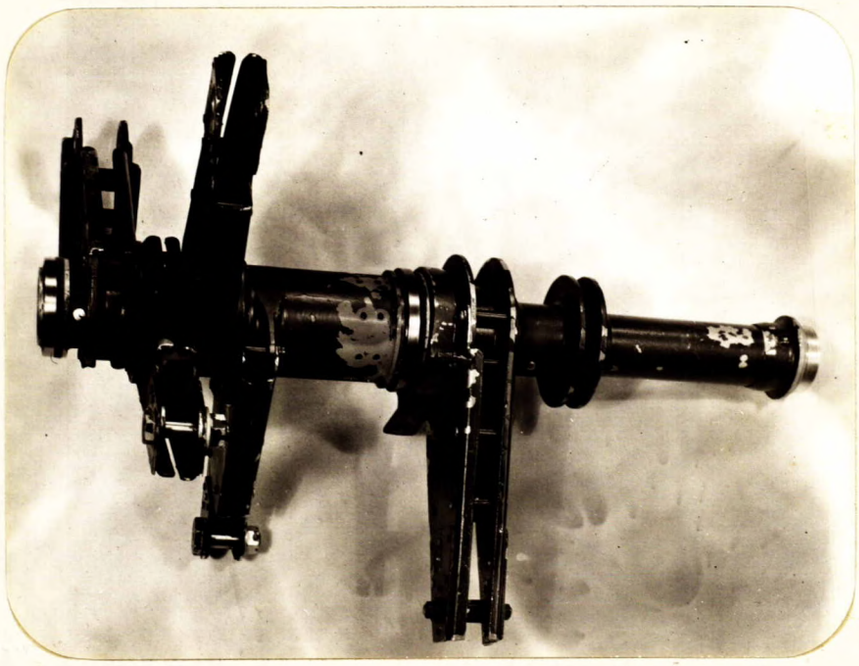
In a letter dated May 7th, 1943 (File No. 938AC-1-5-AMAE DAI), A/C A. L. Johnson, for Chief of the Air Staff, Department of National Defence for Air, Ottawa, Ontario, requested the investigation of the cause of failure of aluminium alloy rivets in an Elevator Control, Front Countershaft Bolingbroke IVT.

It was stated that the rivets should meet the requirements of A.F.S. 259, which specifies the use of aluminium alloy made to B.S. Specification L37 (heat treatment: quick quench from a temperature of 480° ± 10° C. in cold water before use).

Material Received:

Figure 1 shows the elevator control assembly "as received".

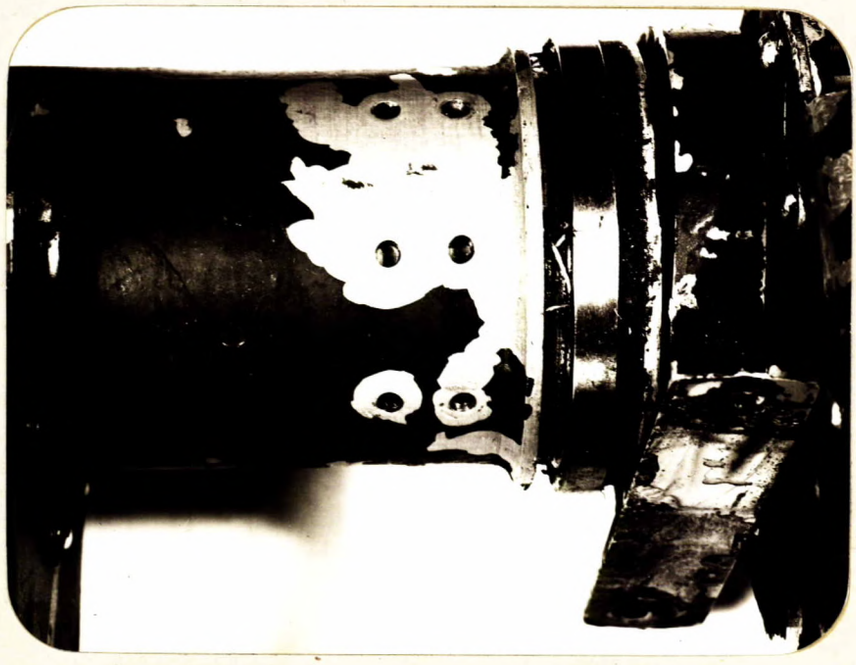
Figure 1.



SAMPLE AS RECEIVED.
(Approximately $\frac{1}{4}$ size.)

Figure 2 shows the failed joint at approximately actual size. The rivet holes in the tubing are visibly deformed.

Figure 2.

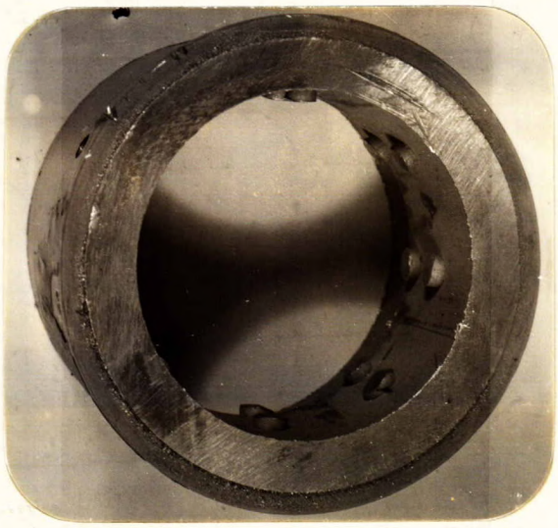


FAILED JOINT.
(Approximately actual size.)

(Material Received, cont'd) -

A broken piece of one of the failed rivets was submitted, and the inner ends of the broken rivets remained in the joint (see Figure 3).

Figure 3.



INNER ENDS OF BROKEN RIVETS
REMAINING IN THE JOINT.

(Approximately actual size).

Chemical Analysis:

		Tubing	Rivets
		- Per cent -	
Copper	-	4.43	4.19
Magnesium	-	0.58	0.64
Manganese	-	0.60	0.61
Iron	-	0.35	0.19
Silicon	-	0.44	0.50
Titanium	-	0.005	-

Hardness:

Hardness was determined by the Vickers method, using a 5-kilogram load.

Rivet - 77 V.H.N.
Tubing - 118 V.H.N.

-

Microscopic Examination:

Figures 4 and 5 show the microstructure of the examined tubing. The structure is normal for an Aluminium Alloy 17ST which was subjected to considerable plastic deformation and later fully heat-treated.

Figure 4.

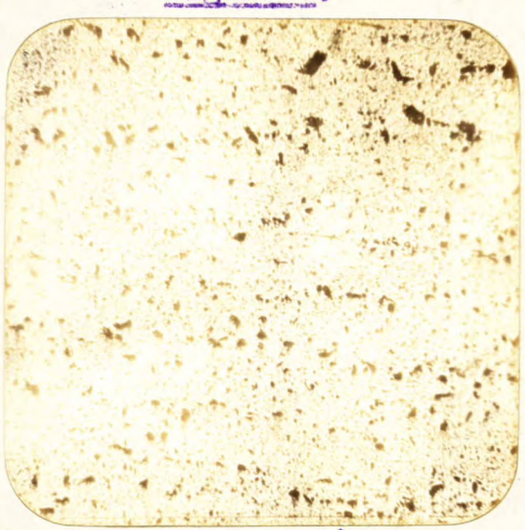
X100, etched*.
TUBING - CROSS-SECTION.

Figure 5.

X100, etched*.
TUBING - LONGITUDINAL SECTION.

Figure 6 shows the microstructure of the submitted piece of rivet. The structure reveals that the material was only annealed and cold-worked (in the joining operation). No proper solution-heat treatment was performed on it.

Figure 6.



X100, etched*.
RIVET - LONGITUDINAL SECTION.

* Etched in Keller's reagent: 1 per cent HFl, 1.5 per cent HCl, 2.5 per cent HNO_3, and 95 per cent H_2O.

British Standard Specification 2L37:

"4. (a) The rods, wire and tubes shall be supplied in the annealed condition.

Note: Rods, wire and tubes, which are not worked within a reasonable time after delivery may have hardened sufficiently to prevent them heading satisfactorily, in which case they should be annealed at a temperature of not less than 360° C. nor more than 400° C."

"15. (a) Rivets shall be supplied in the 'as formed' or 'headed' condition without further treatment, unless otherwise specified on the order.

(b) All rivets shall be heated uniformly at a temperature of 495° C, plus or minus 10° C. and quenched in water immediately before use."

Discussion of Results:

The results of hardness tests and the microscopic examination show that the rivets were used without previous solution-heat treatment.

For comparison of the mechanical properties of Aluminium Alloy 17S wire after different heat treatments, the following table[@] of average values is given:

Alloy		17S-O	17S-T
Heat treatment	=	Annealed	Fully heat treated
Brinell hardness	=	45	100
Ultimate tensile strength, p.s.i.	=	26,000	62,000
Yield strength, p.s.i.	=	10,000	40,000
Elongation, per cent in 2 inches	=	22	22
Shear strength, p.s.i.	=	18,000	38,000
Fatigue strength, p.s.i.		11,000	15,000

The hardness value determined on the examined rivet (77 V.H.N.) is higher than the average given above for annealed material, due to the considerable cold work from the heading

[@] Aluminum Co. of Canada, Ltd., Specifications, February 1942, p. 16.

(Discussion of Results, cont'd) -

and the joining operations, plus some little ageing effect, and also due to the difference in the hardness values as measured by the Brinell and Vickers methods respectively. For these alloys in this range, Vickers hardness values are slightly higher.

CONCLUSIONS:

The rivets used for the failed joint were not solution-heat treated, apparently due to a mistake in the aircraft factory.

The much lower mechanical properties of the used material were certainly a contributing factor to the failure.

oooooooooooo
oooooo
oo

JWM:GHB.